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CAUSES OF MECHANICAL POWER TRANSMISSION ACCIDENTS

JANUARY 1, 1920, TO JULY 1, 1925, IN RELATION TO EXISTING STANDARDS FOR THE GUARDING OF SUCH EQUIPMENT

VICTOR STANISLAUS KARABASZ

A THESIS

IN ECONOMICS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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INTRODUCTION

Purpose and Scope of the Study

The guarding of mechanical power transmission equipment for the purpose of making it safe for the workers has received no small amount of attention ever since the earliest days of accident prevention work. Practically every state in the Union has a set of regulations or a code for the guarding of such equipment, and inasmuch as few of these codes agree, it is obvious that there is a diversity of opinion as to the extent of guarding necessary for safety. In addition to this disagreement one hears, from time to time, in all states, complaints from manufacturers who are compelled to guard types of mechanical power transmission equipment which they do not consider dangerous and who regard the expenditure of moneys in this connection as waste. These manufacturers, on the whole, while not objecting to guarding generally, protest when compelled to protect types of equipment, the hazard of which is not apparent to them. On the other hand, workers for whose protection the guards have been devised, have been known to object to such guards because of the latters interference with production. Workers sometime state that the equipment is more dangerous with than without the guards.

In view of the conditions stated above, it is the purpose of this study, by means of a careful detailed analysis of every mechanical power transmission accident which occurred in the Commonwealth of Pennsylvania from January 1, 1920, to July 1, 1925, to determine the following:

(1) The accident hazards of mechanical power transmission equipment.

(2) Whether or not the existing standards of guarding

mechanical power transmission equipment cover the existing hazards.

(3) Whether or not the present standards of guarding mechanical power transmission equipment are unreasonable insofar as they prescribe for hazards which do not exist.

(4) What recommendations, if any, for changes in the existing mechanical power transmission code of the Commonwealth of Pennsylvania may be justified by the facts unearthed as a result of the study.

Definition of "Mechanical Power Transmission"

As the definition of the term "mechanical power transmission" is not standard throughout the country but varies as used in the safety codes of the various states, it is important to define the term as used in this study. For the purposes of this study, the term "mechanical power transmission" is used as defined in Volume 1, Number 3, Safety Standards of the Pennsylvania Department of Labor and Industry, Mechanical Power Transmission Rules 75 to 85, inclusive, section 2 (b), namely:

> "The term 'Mechanical Power Transmission' shall mean all revolving shafts, pulleys, sheaves, gears, wheels, rotating and reciprocating parts, moving belts and equipment from the prime mover up to but not including the machine driven, or any such parts of the machine which stop when the machine stops."

This definition is used because, first, it is the one used in the existing standards for the guarding of mechanical power transmission equipment in the Commonwealth of Pennsylvania and it is the adequacy of these standards which is being examined in this study; and, secondly, it is the definition which was used in the coding of the accidents over the period studied.

Major Classification of Mechanical Power Transmission Equipment

For the purpose of this study, mechanical power transmission equipment has been divided into three major classes, as follows: (1) Belts and Pulleys, (2) Shafts, and (3) Gears.

In the Belt and Pulley classification are included, in addition to belts and pulleys, such types of transmission equipment as ropes, sheaves, cables, drums, chains, and sprockets.

The "Shaft" classification includes all shaft equipment such as collars, couplings, set screws, keys, bolts and clutches.

The "Gear" classification includes all types of mechanical power transmission gears.

The above classification serves the purposes of this study very well inasmuch as the accident hazards involved in every one of the three classes are different, yet the accident hazards within any one class are similar. This makes it possible to study types of equipment which have similar accident hazards as a group.

Method of Study

The fundamental data used in the making of this study were (1) the mechanical power transmission accident reports for the period studied, on file in the Bureau of Workmen's Compensation; (2) the accident investigation reports of such of the accidents studied as had already been investigated by the Accident Investigation Section of the Department of Labor and Industry; (3) personal visits to a large group of plants in which mechanical power transmission accidents had occurred; and (4) conferences with plant executives, safety engineers, manufacturers and jobbers of mechanical power transmission equipment, and executives of insurance companies carrying Workmen's Compensation Insurance.

Accident Reports

Every industrial accident in the Commonwealth of Pennsylvania, in which the resulting disability is of two days or more duration must be reported to the Bureau of Workmen's Compensation of the Department of Labor and Industry. For this purpose, a standard accident report form (Appendix A) is used. An important section of the Accident Report is that referring to the cause of the accident, and the conditions under which the accident occurred. Upon the receipt of the accident report by the Bureau of Workmen's Compensation, it is given a number and coded for cause, industry and other pertinent information. This coded information is punched upon Hollerith Tabulating Cards and the report is then filed in the Bureau. The Hollerith cards are used for current tabulations of statistics and are then filed away by years, every year's cards being divided by industry.

In order to ascertain which of the more than 1,800,000 accidents on file in the Bureau of Workmen's Compensation pertained to mechanical power transmission equipment, it was necessary to sort the Hollerith cards, for the period studied, for those which were punched with the mechanical power transmission code number in the cause column of the card. From these cards the accident report numbers of the mechanical power transmission accidents were obtained, and as the accident reports are filed in numerical order, it was a simple matter to obtain the original accident reports.

Every accident reported to the Bureau of Workmen's Compensation from January 1, 1920, to July 1, 1925, and coded as being caused by mechanical power transmission equipment was carefully studied with the following exceptions:

(1) For the years 1920 and 1921 only the compensable accidents were studied. A compensable accident is one in which the resulting disability is more than 10 days. The Hollerith cards from which the accident report numbers had

to be obtained were not available for non-compensable accidents of 1920 and 1921.

(2) Inasmuch as the Department of Labor and Industry has no authority over accidents occurring in coal mines, either anthracite or bituminous, mechanical power transmission accidents in the coal mining industry are not included.

(3) Only such non-train mechanical power transmission accidents of public utility companies, as occur to persons engaged in intra-state commerce are reportable to the Department of Labor and Industry and are included in this study.

As a result of following the procedure outlined it was found that in the five and one-half year period studied 10,077 accidents had been coded as having been caused by mechanical power transmission equipment. The careful study of these 10,077 accident reports revealed, however, that only 1386 were actually mechanical power transmission accidents according to the definition of the code. This great difference between the coded number of accidents and the actual number was due to the inexperience of the coders and their lack of familiarity with the definition of mechanical power transmission as used in the code. Their greatest error was in coding distinctly "machine" accidents as mechanical power transmission accidents.

The failure to code the mechanical power transmission accidents properly, immediately raises the question as to whether or not all the mechanical power transmission accidents were included under that heading. A glance at Table I, Classification of Causes of Accidents, immediately indicates that the only other classification under which transmission accidents were likely to be included was that of "Machinery." A careful check was made of the accidents in this classification during selected months of the five and one-half year period to ascertain whether transmission accidents had been improperly included. No transmission accidents could be found in this classification in any of

these months, the error having been the placing of machinery accidents under transmission rather than vice versa. With this check it is likely that all of the transmission accidents of the period were obtained.

TABLE I

CLASSIFICATION OF CAUSES OF ACCIDENTS
DEPARTMENT OF LABOR AND INDUSTRY
Commonwealth of Pennsylvania

Machinery	
Boilers	
Pumps, Compressors and Prime Movers	
Transmission	
Elevators	
Cranes and Derricks	
Cars and Engines	
Motor Vehicles	
Horse Vehicles	
Hand Trucks	
Water Craft	
Handling Objects	
Hand Tools	
Electricity	
Explosives and Explosions	
Hot and Corrosive Substances	
Falling Objects	
Falling Objects (Mines and Quarries)	
Fall of Persons	
Stepping Upon or Striking Against Objects	
Miscellaneous Causes	

Upon a large form (Appendix B) all of the pertinent information from the accident reports was recorded. This included the accident report number, the name of the concern, the industry, the location of the factory, the occupation of the injured person, work at time of the accident, department code number, part of transmission upon which accident occurred, length of experience on job, nature of injury, days lost, detailed cause of accident and remarks as to cause of the accident.

A study of this compilation of all accidents showed that the existing cause of classification (Appendix C) would be of little value in giving a detailed statement of causes from the standpoint of the part of the transmission equipment

involved in the accident, and it was therefore necessary to develop a new cause classification which would give the desired detail. (Appendix D.)

All of the accidents were then recoded according to the newly developed classification and this information was then punched into the Hollerith cards from which cards all the statistical tabulations in this study are obtained.

Accident Investigation Reports

The Accident Investigation Section of the Department of Labor and Industry investigates many of the serious accidents which occur in the Commonwealth and the records of this Bureau were used in some cases to obtain additional information on specific accidents. These accident investigations are made by factory inspectors and reported on "Accident Investigation Reports" (Appendix E).

Personal Investigations of Accidents

In many instances the cause of the accident as stated in the accident report was vague and indefinite and before the real cause could be ascertained, a trip to the factory had to be made to obtain more detailed and accurate information, and to observe at first hand the actual conditions under which the accident occurred. Wherever possible the injured and the employer were interviewed. In all, over 100 personal investigations in all parts of the State were made.

Conferences

Numerous conferences were also held with plant executives, safety engineers, manufacturers of and dealers in mechanical power transmission equipment and insurance company executives on the subject matter in general and on specific phases of the study.

CHAPTER I

Importance of Mechanical Power Transmission Accidents

Mechanical Power Transmission equipment is without a doubt the best guarded class of equipment in Pennsylvania as it is indeed in most states. Since the earliest days of factory inspection work, the guarding of this type of equipment has been emphasized and even today a very large percentage of the orders issued by factory inspectors pertain to this equipment. The paucity of accidents in connection with mechanical power transmission equipment is therefore not surprising. Table II clearly shows the small number of transmission accidents compared with the total of accidents from all causes. This small number of accidents has caused many people to raise the question as to whether or not too much emphasis has been placed upon mechanical power transmission equipment at the expense of neglecting equally dangerous if not more dangerous types of equipment.

TABLE II

Mechanical Power Transmission Accidents Compared With Total Number of Industrial Accidents, State of Pennsylvania (Excludes Coal Mining Accidents)

	1920	1921	1922	1923	1924	1925 (6 Mos.)	Total
Total No. of Accidents	127,192	89,441	109,642	140,553	123,090	63,941	653,859
Mechanical Power Transmission Accidents	224*	180*	322	454	144	62	1,386
%	00.17	00.20	00.29	00.32	00.11	00.09	00.21

* Compensable only.

Table III, which is a classification by cause of all compensable accidents in the State of Pennsylvania, for the first

TABLE IV

Mechanical Power Transmission Accidents, January 1, 1920, to July 1, 1925, by Years

Commonwealth of Pennsylvania

Part of Transmission	1920*				1921*				1922				1923				1924				1925 (6 Mos.)				TOTAL			
	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.
Belts-Pulley	6	177	...	183	5	148	...	153	5	169	111	285	6	205	154	365	6	54	46	106	3	24	17	44	31	777	328	1136
Shafts	7	21	...	28	4	17	...	21	5	17	10	32	8	38	13	59	3	21	11	35	6	9	3	18	33	123	37	193
Gears	1	12	...	13	1	5	...	6	..	4	1	5	1	25	4	30	1	1	1	3	..	..	..	..	4	47	6	57
Total	14	210	...	224	10	170	...	180	10	190	122	322	15	268	171	454	10	76	58	144	9	33	20	62	68	947	371	1386

* Non-compensable Accidents not used 1920-1921.

F = Fatal.

10+ = More than 10 days' disability.

10— = Ten days or less disability.

six months of 1926 shows "Transmission" the least important cause of accidents in a list of 21 causes, being even less important than "Water Craft."

TABLE III

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF LABOR AND INDUSTRY
BUREAU OF STATISTICS

Compensated Accidents During the First Six Months of 1926, Compiled from Records in the Bureau of Workmen's Compensation

	Total of All Industries	
	*F	NF
Total of All Causes	840	36,189
Machinery	39	4,015
Boilers	7	18
Pumps, Compressors and Prime Movers	5	192
Transmission	1	27
Elevators	19	226
Cranes and Derricks	39	1,024
Cars and Engines	132	4,100
Motor Vehicles	67	2,051
Horse Vehicles	9	547
Hand Trucks	5	773
Water Craft	7	23
Handling Objects	31	6,827
Hand Tools	8	2,708
Electricity	21	167
Explosives and Explosions	69	355
Hot and Corrosive Substances	36	1,266
Falling Objects	35	2,102
Falling Objects (Mines and Quarries)	191	2,932
Fall of Persons	87	4,511
Stepping Upon or Striking Against Objects	9	1,516
Miscellaneous Causes	23	809

*Fatal. NF—Non-fatal.

In examining the importance of the various classes of mechanical power transmission equipment from the standpoint of the number of accidents caused by each class of transmission equipment, reference to Table IV shows that Belts and Pulleys are responsible for 1136 or 81.9% of all transmission accidents, Shafts for 193 or 13.9% of all transmission accidents and Gears for 57 or 4.2% of such accidents. Therefore, from the viewpoint of the number of accidents caused, Belts and Pulleys are almost six times as

important as Shafts and almost twenty times as important as Gears.

While mechanical power transmission accidents are relatively few in number when compared with the total of accidents from all causes, nevertheless, when such accidents do occur they are usually quite serious. Table V shows that 15.3% of Shaft accidents are fatal, whereas only 5.3% of Gear accidents and 2.5% of Pulley accidents resulted in death. Shafts and Gears, while only causing 18.6% of the mechanical power transmission accidents from Jan. 1, 1922, to July 1, 1926, show a much higher percentage of fatalities than Belts and Pulleys which caused 81.4% of the transmission accidents in the same period.

TABLE V

MECHANICAL POWER TRANSMISSION ACCIDENTS, JANUARY 1, 1922, TO JULY 1, 1925, BY CLASS OF TRANSMISSION IN % ACCORDING TO DEGREE OF SERIOUSNESS AND RELATION TO TOTAL OF ALL TRANSMISSION ACCIDENTS FOR THE PERIOD*

Part of Transmission	% Fatal	% 10+	%10—	% of All Mechanical Power Transmission Accidents
Belts and Pulley ...	2.5	56.5	41.0	81.4
Shafts	15.3	59.0	25.7	14.6
Gears	5.3	79.0	15.7	4.0

10+ = Disability more than 10 days.
10— = Disability 10 days or less.

* Statistics covering non-compensable accidents are not available for 1920 and 1921.

Table VI shows the distribution of mechanical power transmission accidents by industries over the period studied. The total and the percentage of fatal accidents in each industry, as well as the total and the percentage of accidents which resulted in more than ten days disability and ten days and less disability are also shown.

Table VII shows the wide distribution of mechanical power transmission accidents by occupation. No occupation in the plant, from that of superintendent to that of laborer is free from this type of accident. The large num-

Industry	1920				1921					
	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+
1. Building and Contracting		1	..	1	1	2	..	3	..	..
2. Chemical and Allied Products	2	6	..	8	..	2	..	2	1	7
3. Clay, Glass and Stone Products	3	18	..	21	1	18	..	19	2	20
4. Clothing Manufacture		8	..	8	..	15	..	15	..	9
5. Food and Kindred Products	1	17	..	18	..	16	..	16	..	12
6. Leather, Rubber Composition Goods		5	..	5	..	8	..	8	..	5
7. Liquors and Beverages		..	..	..	..	..	..	..	..	..
8. Lumber and Its Remanufacture	1	18	..	19	2	13	..	15	..	19
9. Paper and Printing Ind.		8	..	8	..	6	..	6	..	4
10. Textiles		26	..	26	..	17	..	17	1	30
11. Laundries	1	1	..	2	..	3	..	3	1	1
12. Metal and Metal Products	5	80	..	85	4	50	..	54	3	54
13. Transportation Public Utilities		3	..	3	..	2	..	2	1	5
14. Quarries and Mines (Other Than Coal)		1	..	1	..	3	..	3	1	6
15. Tobacco and Its Products		..	..	..	..	3	..	3	..	2
16. Miscellaneous Industries	1	16	..	17	2	10	..	12	..	11
17. Hotels and Restaurants		1	..	1	..	..	..	..	..	..
18. Mercantile Establishments		..	..	..	..	2	..	2	..	4
19. Jobbers and Warehouses		1	..	1	..	..	..	..	..	..
20. Municipalities		..	..	..	..	..	..	..	..	1
TOTAL	14	210	..	224	10	170	..	180	10	190

F = Fatal accident.
10+ = More than 10 days' disability.
10— = Ten days or less disability.

TABLE VI

CCIDENTS JANUARY 1, 1920, TO JULY 1, 1925, BY INDUSTRIES

1922			1923			1924				1925 (6 Mos.)				TOTAL				TOTAL %			
10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.
..	..	..	3	..	3	..	..	1	1	..	2	..	2	1	8	1	10	10	80	10	100
4	12	1	9	1	11	..	9	4	13	1	5	1	7	5	38	10	53	9.4	71.7	18.9	100
7	29	1	22	11	34	3	10	10	23	3	5	4	12	13	93	32	138	9.4	67.4	23.2	100
5	14	..	19	4	23	..	..	2	2	..	..	..	..	..	51	11	62	...	82.2	17.8	100
2	14	..	18	5	23	2	2	4	8	1	2	2	5	4	67	13	84	4.7	79.7	15.6	100
4	9	..	6	6	12	..	1	2	3	1	1	..	2	1	26	12	39	2.5	66.7	30.8	100
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...	...
9	28	1	18	11	30	1	5	3	9	..	3	1	4	5	76	24	105	4.8	72.4	22.8	100
12	16	..	8	7	15	..	8	5	13	1	1	2	4	1	35	26	62	1.6	56.4	42.0	100
23	54	1	41	30	72	..	4	2	6	..	2	2	4	2	120	57	679	1.1	67.0	31.9	100
1	3	..	3	3	6	..	1	4	5	..	..	..	..	2	9	8	19	10.5	47.3	42.2	100
46	103	9	84	60	153	3	24	17	44	1	8	8	17	25	300	131	456	5.5	65.7	28.8	100
5	11	..	6	16	22	..	4	1	5	..	1	..	1	1	21	22	44	2.3	47.7	50.0	100
..	7	2	9	7	18	1	3	..	4	1	..	..	1	5	22	7	34	15.0	64.5	20.5	100
..	2	..	2	1	3	..	..	..	..	..	..	..	..	0	7	1	8	...	87.5	12.5	100
4	15	..	14	9	23	..	4	3	7	..	1	..	1	3	56	16	75	4.0	74.6	21.4	100
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	...	100	...	100
..	4	..	2	..	2	..	..	..	..	..	..	..	..	..	8	..	8	...	100	...	100
..	..	..	1	..	1	..	1	..	1	..	..	..	..	..	3	..	3	...	100	...	100
..	1	..	3	..	3	..	..	..	..	..	2	..	2	..	6	..	6	...	100	...	100
122	322	15	268	171	454	10	76	58	144	9	33	20	62	68	947	371	1386	4.9	68.3	26.8	100

ber of accidents occurring to machine operators and laborers is significant and directs attention to the importance of studying the possibilities of reducing mechanical power transmission accidents in these occupations. The figures for the other occupations are also valuable from an accident reduction viewpoint.

TABLE VII

NUMBER OF MECHANICAL POWER TRANSMISSION ACCIDENTS BY OCCUPATIONS OF PERSONS INJURED

	Number of Accidents			
Occupation	Belt and Pulley	Shaft	Gear	Total
1. Millwright	14	21	2	37
2. Millwright's Helper	30	..	..	30
3. Machinist	38	12	1	51
4. Machine Operator	733	75	27	835
5. Repairman and Oiler	70	27	10	107
6. Laborer	85	22	7	114
7. Helper	53	15	6	74
8. Engineer	25	8	2	35
9. Superintendent	3	..	..	3
10. Foreman	31	3	1	35
11. Not Otherwise Classified	54	10	1	65
	1136	193	57	1386

PSYCHOLOGICAL DANGER RESULTING FROM SMALL NUMBER OF ACCIDENTS

In a number of plants, visited during the study, it was found that the transmission accident being investigated was the first accident from that cause happening in those plants for a number of years. In one plant, it was the only accident from that cause in twenty years and others had freedom from this type of accident from five, ten and fifteen years. When one considers the relatively few accidents of this kind occurring in all industries, it is not surprising to find that this is the case. However, this scarcity of accidents causes carelessness and the rise of the feeling on the part of the workers that mechanical power transmission equipment is not dangerous. With the develop-

ment of this feeling, reckless and dangerous methods are used, which sooner or later result in accidents. While there may not be very many mechanical power transmission accidents it has been shown that those which do occur are usually serious.

Summary

During the 4½ year period studied, mechanical power transmission accidents consisted of only 0.2 of 1% of the total of all the accidents from all causes. In a classification of twenty-one causes of accidents used by the Department of Labor and Industry, "Transmission" is the least important cause. Belts and Pulleys as a class caused 1136 or 81.9% of all mechanical power transmisison accidents over the period studied; whereas Shafts as a class caused 193 or 13.9%, and Gears as a class 57 or 4.2% of such accidents. As a class, Belts and Pulleys cause almost six times as many accidents as Shafts, and almost twenty times as many accidents as Gears. During the period of January 1, 1922, to July 1, 1925, 15.3% of all Shaft accidents were fatal; 5.3% of all Gear accidents and 2.5% of all Belt and Pulley accidents also resulted in fatalities during the same period. This means that the percentage of fatalities in Shaft accidents is about six times that of Belts and Pulleys and about three times that of Gears. These figures show the seriousness of mechanical power transmission accidents. Three occupations—machine operator, laborer, and repairman and oiler—were responsible for 1056 out of the 1386 mechanical power transmission accidents. The paucity of mechanical power transmission accidents in specific factories and in industry in general leads to carelessness and reckless methods which sooner or later lead to accidents.

Belt and Pulley Accidents

By Part

Part of Transmission	*All Exposures*					*Operating Machine*					*Repairing and Testing*					*Shiftin*	
	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	
All Parts	31	19	757	329	1136	..	3	106	39	148	4	3	82	23	112	14	
Caught Between Belt and Pulley	11	9	403	145	568	.	..	40	14	54	2	1 Arm	27	5	35	5	5
Contact With Moving Belt	2	..	74	49	125	..	..	13	8	21	..	..	17	4	21	..	1
Belt Other Than Direct Physical Contact	8	..	47	30	85	..	..	1	1	2	..	..	..	1	1	6 (C)	
Belt Breaking, Struck by End	2	3 Eyes	58	29	92 (D)	..	2 Eyes	23	9	34	..	..	1	4	5	1	1
Belt Lacing, Not Broken Belt	1	..	41	31	73	..	..	6	2	8	..	..	6	1	7	..	
Belt Winding on Shafting	4	1 Arm	16	1	22	..	1 Arm	4	..	5	2	..	9	..	11	2	
Belt Running Off Pulley	..	1 Arm	14	10	25	..	..	4	1	5	..	..	2	1	3	..	
Caught by Pulley	2	1 Arm	68	26	98	..	..	9	2	11	..	..	12	5	17	..	1
Chains and Sprockets	1	1 Leg 2 Arms 1 Hand	33	4	41	..	..	6	1	7	..	1 Hand 1 Arm	8	..	10	..	1
Ropes, Cables, Sheaves —Drums	..	..	3	4	7	..	..	..	1	1	..	..	..	2	2	..	

F. & P.T.D. = Fatal and permanent total disability.
P.D. = Permanent disability.
10+ = Disability of more than 10 days' duration.
10— = Disability of 10 days or less duration.

(A) 437 shifting or applying by hand.
(B) 297 shifting or applying by hand.
(C) All the result of using pole or stick.
(D) 10 belt lacing, broken belt.

TABLE IX

NWEALTH OF PENNSYLVANIA
IENT OF LABOR AND INDUSTRY
BUREAU OF STATISTICS

Pennsylvania—January 1, 1920, to July 1, 1925

of Transmission and Exposure

	or Applying Belt			*Oiling or Cleaning*					*Applying Belt Dressing*					*Passing, Looking On, Working Near*					*Not Otherwise Classified*				
D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total
9	316	152	491 (A)	4	1	69	35	109	4	..	97	27	128	5	1	70	50	126	..	2	17	3	22
rms g'r	206	88	305 (B)	2	1 F'g'r	35	18	56	1	..	73	16	90	1	..	17	4	22	..	1 Leg	5	..	6
.	17	13	30	1	..	8	5	14	1	..	12	8	21	..	..	7	11	18	..	..	..	..	..
.	31	22	59	..	..	2	3	5	2	..	5	..	7	..	..	..	1	1	..	..	8	2	10
ye	9	1	12	..	..	2	..	2	..	..	1	..	1	1	..	22	15	38	..	..	..	..	..
.	17	19	36	..	..	3	1	4	..	..	3	2	5	1	..	6	6	13	..	..	..	..	..
.	2	..	4	..	..	..	..	..	..	..	..	..	..	..	..	1	1	2	..	..	..	..	..
.	2	2	4	..	..	2	1	3	..	..	..	..	..	..	..	4	5	9	..	1 Arm	..	..	1
rm eg	24	6	32	..	..	9	6	15	..	..	3	1	4	2	..	8	5	15	..	..	3	1	4
.	5	1	6	1	..	8	1	10	..	..	..	..	..	..	1 Arm	5	1	7	..	..	1	..	1
.	3	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..

CHAPTER II

Causes of Mechanical Power Transmission Accidents

In studying the causes of mechanical power transmission accidents, the classifications of equipment, part of equipment and exposure previously mentioned are used.

Belts and Pulleys

Causes by Part of Transmission and Exposure

Table *IX* shows the causes of belt and pulley mechanical power transmission accidents by part of transmission and by exposure. An analysis of this table shows very convincingly the parts of the transmission equipment at which belt and pulley accidents occur and the exposures which result in the largest number of accidents.

Caught Between Belt and Pulley

Exactly one-half or 568, of the total of 1136 belt and pulley accidents are the result of the injured being caught between the belt and pulley. These figures definitely show that the exposed nip-point of the belt and pulley is the greatest single hazard not only in the belt and pulley classification of transmission accidents but of all mechanical power transmission equipment. Eleven of these accidents resulted in death or permanent total disability, nine in permanent disability, 403 in disability of more than ten days and 145 in disability of ten days or less.

The most important exposure causing workers to be caught between belt and pulley is that of shifting or applying belt which resulted in 305 of the total of 568 accidents resulting from all exposures, 297 of these accidents resulted from shifting or applying belt by hand. Of the 305 acci-

dents caused by shifting or applying belt, 5 resulted in death or permanent total disability, 6 in permanent disabilities, 206 in disability lasting beyond 10 days and 88 in disability of 10 days or less. It is well to note here the seriousness of accidents resulting from shifting or applying belt.

The next important exposure in causing workers to be caught between belt and pulley is that of applying belt dressing. Belt dressing is usually applied while the belt is in motion and the guard is removed and very often it is applied to the portion of the belt running on to the pulley rather than the portion coming off of the pulley. A total of 90 accidents resulted from this cause, one of which was fatal, 73 of which resulted in disability of more than ten days and 16 in disability of ten days or less. Of the remaining exposures, oiling or cleaning resulted in 56 accidents; operating machine resulted in 54 accidents; repairing or testing 35; passing, looking on or working near 22; and not otherwise classified in 6 accidents.

Contact with Moving Belt

In this classification have been placed all accidents which have been the result of direct physical contact with the moving belt. A total of 125 accidents fall into this class, of which 2 are fatal or permanent total disabilities; none are permanent disabilities; 74 resulted in disability of more than 10 days and 49 resulted in disability of 10 days or less. Shifting or applying belt is again the most important exposure leading to these accidents, 30 having been so caused. Applying belt dressing, operating machine, and repairing and testing were responsible for 21 accidents each; while passing, looking on and working near resulted in 18, and oiling or cleaning machine resulted in 14 accidents.

Belt—Other Than Direct Physical Contact

In this classification have been placed all accidents which have been caused by the belt but not by the direct physical

contact of the worker with the belt. Such an accident would be the shifting of a belt by means of a pole where the pole coming into contact with the spokes of the pulley kicks back and injures the worker. As this is a type of hazard which is separate and distinct from direct physical contact of worker with belt, it was necessary to set up a separate classification. A total of 85 accidents fall into this class, of which 8 were fatal or permanent total disabilities, 47 resulted in disability of more than 10 days and 30 in disability of 10 days or less; 59 of the total of 85 accidents were caused by shifting or applying belt. Of these 59, 6 resulted in fatalities, all the result of using a pole or stick to shift belt; 31 resulted in disability of more than 10 days and 22 in disability of 10 days or less. All of the remaining exposures resulted in 10 accidents or less apiece. There were two fatal accidents as a result of applying belt dressing. In both these cases stick belt dressing was used.

Belt Breaking—Struck by End

In this classification have been placed all accidents which were the result of the belt breaking or parting, while in motion, and the end of the belt hitting the worker, causing the injury. Of a total of 92 accidents resulting from this cause, 2 proved to be fatal, 3 were permanent disabilities, 58 resulted in more than ten days' disability, and 29 resulted in disability lasting ten days or less. Of the total of 92 accidents, 10 were the result of flying belt lacing.

The most important exposure under this classification is that of passing, looking on or working near, which caused a total of 38 accidents, one of which was fatal. Operating machine was an exposure resulting in 34 accidents, while shifting or applying belt caused a total of 12 accidents, one of which was fatal. The remaining three exposures caused a total of 8 accidents.

Belt Lacing, Not Broken Belt

In this classification were placed all accidents caused primarily by belt lacing of any kind. A total of 73 accidents resulted from all exposures, one of which was fatal, 41 resulting in disability of longer than ten days, and 31 in ten days or less disability. Almost one-half, 36 accidents resulted from shifting or applying belt, again emphasizing the importance of this exposure as a cause of belt and pulley accidents; 13 of the total of 73 accidents were caused while the worker was exposed by passing, looking on or working near, one of these accidents having been fatal. The remaining accidents in this classification are scattered among the other four exposures.

Belt Winding on Shafting

All accidents in which the belt having fallen or been removed from the pulley, because of a rough shaft or some other reason, winds upon the shaft catching the worker's hand or arm as it winds up have been placed in this classification. Sometimes the worker is pulled off the floor to the shaft, or the machine at which the worker is being employed is pulled over upon the worker, injuring or killing the worker. This class of accident has a high fatality rate. Out of a total of 22 accidents resulting from all exposures 4 or over 18% were fatal, 1 resulted in permanent disability, 16 in disability of more than 10 days and 1 in disability of 10 days or less. Repairing and testing is the exposure causing the largest number of accidents of this class with a total of 11 accidents, 2 of which were fatal and 9 resulting in disability of more than 10 days. Shifting or applying belt is again an important exposure in this type of accident with 2 fatal and 2 accidents of more than 10 days' disability. The remaining 7 accidents resulted from two exposures, namely, operating machine and passing, looking on and working near.

Belt Running Off Pulley

This type of accident usually results where there is a pulley hung on the end of a shaft with no hanger or device to prevent the belt it is carrying from running off the pulley and falling. There were a total of 25 such accidents from all exposures, none of which were fatal, although 1 permanent disability resulted. 14 accidents resulted in disability lasting more than 10 days and 10 accidents resulted in disability of 10 days or less. The accidents in this classification were scattered rather evenly in all exposures excepting that of applying belt dressing, in which exposure there were no accidents.

Caught by Pulley

All accidents which were the results of the injured being caught in the spokes of a pulley or being cut by the edge of the pulley were placed under this classification. There was a total of 98 such accidents, of which 2 were fatal, 2 resulted in permanent disability, 68 in disability of more than 10 days, and 26 in disability of 10 days or less. Shifting or applying belt is again the most important exposure causing this type of accident, slightly less than one-third of the total being so caused. Repairing and testing was the exposure causing 17 of this class of accidents, while oiling and cleaning, and passing, looking on and working near each caused 15, operating machine caused 11, applying belt dressing 2, and not otherwise classified 4.

Chains and Sprockets

All accidents in which mechanical power transmission chains were involved in any way are included in this clasification. Compared with belts and pulleys proper there are relatively few accidents from this cause. The danger of this equipment is readily recognized and consequently the equipment is very often well guarded. There was a total

of 41 accidents resulting from all exposures, one of which was fatal, 3 permanent disabilities, 33 resulting in disability of more than 10 days' duration and 4 in disability of 10 days or less duration. Oiling and cleaning, and repairing and testing each caused a total of 10 accidents, or approximately one-half of the total number of accidents from all exposures. The remainder of the accidents are scattered among the other exposures excepting applying belt dressing which exposure caused no accidents.

Ropes, Cables, Sheaves, Drums

Ropes, cables, sheaves and drums, compared with belts and pulleys, are types of transmission equipment which are relatively unimportant. Only 7 accidents resulted in connection with this equipment, none of which were fatal or permanent disabilities. Shifting or applying is again the most important exposure resulting in 3 accidents; repairing and testing resulted in two, and operating machine and passing, looking on or working near resulted in one accident each.

Causes by Industry

Table *X* shows Belt and Pulley accidents for the period studied by Industry. The industry having the largest number of belt and pulley accidents is the Metal and Metal Products Industry. This is to be expected, because this industry is the most important in the State. The most significant feature of Table X is the relatively large number of fatal accidents, in the Clay, Glass and Stone Industries, the Chemical and Allied Products Industries and the Lumber and its Remanufacture Industries. The number of fatal accidents in these industries is entirely out of line with the average for all industries which is 2.7%. The Chemical and Allied Industries have a percentage of 8.8 fatal; the Lumber and its Remanufacture Industry have 5.3% fatal; and the Clay, Glass and Stone Industries have 6.4% fatal.

TABLE X

BELT AND PULLEY ACCIDENTS BY INDUSTRIES
JANUARY 1, 1920, TO JULY 1, 1925 (6 MOS.)

Industry	1920				1921				1922				1923				1924				1925 (6 Mos.)				TOTAL			
	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.
1. Building and Contracting		1	..	1	1	1	..	2	..	..	..	..	..	..	..	..	..	..	1	1	..	1	..	1	1	3	1	5
2. Chemical and Allied Products	1	5	..	6	..	2	..	2	1	7	2	10	1	3	..	4	..	5	3	8	..	3	1	4	3	25	6	34
3. Clay, Glass and Stone		14	..	14	..	16	..	16	2	14	7	23	1	13	11	25	2	9	10	21	2	5	3	10	7	71	31	109
4. Clothing Manufacture		8	..	8	..	12	..	12	..	9	3	12	..	15	4	19	..	..	..	..	..	..	..	..	..	44	7	51
5. Food and Kindred Products		14	..	14	..	13	..	13	..	11	2	13	..	13	3	16	1	1	2	4	..	2	1	3	1	54	8	63
6. Leather, Rubber Composition Goods		4	..	4	..	7	..	7	..	4	4	8	..	6	6	12	..	..	2	2	..	1	..	1	..	22	12	34
7. Liquors and Beverages		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8. Lumber and Its Remanufacture	1	16	..	17	2	11	..	13	..	17	9	26	1	17	10	28	1	3	3	7	..	2	1	3	5	66	23	94
9. Paper and Printing		6	..	6	..	6	..	6	..	3	11	14	..	6	6	12	..	6	4	10	1	1	2	4	1	28	23	52
10. Textiles		22	..	22	..	16	..	16	..	26	22	48	1	30	27	58	..	3	..	3	..	2	2	4	1	99	51	151
11. Laundries	1	1	..	2	..	3	..	3	..	1	1	2	..	2	3	5	..	1	3	4	..	..	..	..	1	8	7	16
12. Metals and Metal Products	2	71	..	73	2	46	..	48	2	51	41	94	2	70	56	129	1	16	14	31	..	5	7	12	9	259	118	386
13. Transportation Public Utilities		2	..	2	..	..	..	..	..	5	5	10	..	4	14	18	..	3	1	4	..	..	..	..	..	14	20	34
14. Quarries and Mines—Not Coal		..	..	..	..	2	..	2	..	4	..	4	..	8	7	15	1	2	..	3	..	..	..	..	1	16	7	24
15. Tobacco and Its Products		..	..	..	..	3	..	3	..	2	..	2	..	2	..	2	..	..	..	..	..	..	..	..	..	7	..	7
16. Miscellaneous Industries	1	11	..	12	..	9	..	9	..	10	4	14	..	11	7	18	..	4	3	7	..	1	..	1	1	46	14	61
17. Hotels and Restaurants		1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
18. Mercantile Establishments		..	..	..	..	1	..	1	..	4	..	4	..	1	..	1	..	..	..	..	..	..	..	..	..	6	..	6
19. Jobbers and Warehouses		1	..	1	..	..	..	..	..	1	..	1	..	1	..	1	..	1	..	1	..	..	..	..	..	3	..	3
20. Municipalities		..	..	..	..	..	..	..					..	3	..	3	..	..	..	..	..	1	..	1	..	5	..	5
TOTAL	6	177	..	183	5	148	..	153	5	169	111	285	6	205	154	365	6	54	46	106	3	24	17	44	31	777	328	1136

F = Fatal.
10+ = More than 10 days' disability.
10— = Ten days or less disability.
Ttl. = Total

Causes by Occupation of Injured

Table *XI* is an analysis of belt and pulley accidents by occupation. The significant feature of this table is that it shows that the largest number of belt and pulley accidents are occurring, not to the millwright, millwright's helper or repairman and oiler, those trained in mechanical power transmission equipment, but to the machine operator, who knows practically nothing of such equipment. The table also indicates that practically every one in the factory from superintendent down to the laborer is called upon to handle mechanical power transmission equipment. This information will be of value from an accident prevention viewpoint.

TABLE XI

Analysis of All Belt and Pulley Accidents by Occupation of Injured, January 1, 1920, to July 1, 1925

Occupation	No. of Accidents
1. Millwright	14
2. Millwright's Helper	30
3. Machinist	38
4. Machine Operator	733
5. Repairman and Oiler	70
6. Laborer	85
7. Helper	53
8. Engineer	25
9. Superintendent	3
10. Foreman	31
11. Not Otherwise Classified	54
	1136

Shafts

Causes by Part of Transmission and Exposure

Table *XII* is an analysis of mechanical power transmission shaft accidents by part of transmission and by exposure. It indicates clearly where and how shaft and shaft equipment accidents are occurring. The classification of part of transmission and exposure developed earlier in the study for shafts is here used.

Shafts—Smooth Between Bearings

One sometimes hears it said that *smooth* shafts are not dangerous. A glance of Table XII shows that out of a total of 193 shaft and shaft equipment accidents 156 or 80.8% were in connection with smooth shafts between bearings, 70 of the total of 156 accidents, resulted from passing, looking on or working near shafts, of which 12 were fatal, 1 was a permanent disability, 41 resulted in disability of more than 10 days and 16 resulted in disability of ten days or less.

Thirty-two smooth shaft accidents occurred while repairing and testing machine of which number 5 were fatal, 1 resulted in a permanent disability, 24 in disability of more than 10 days and 2 in disability of 10 days or less.

Twenty more smooth shaft accidents occurred while shifting or applying belt. Of these 4 were fatal, 1 was a permanent disability, 10 resulted in more than 10 days disability and 5 in disability of 10 days or less.

The exposure, oiling and cleaning, resulted in 19 smooth shaft accidents. Five of these accidents were fatal, 13 resulted in disability of more than 10 days' duration and 1 in disability of 10 days or less duration. Other exposures resulting in smooth shaft accidents were, operating machine 4, applying belt dressing 1, and not otherwise classified 10.

Shafts—Collars and Couplings

All accidents resulting in any manner from collars or couplings were placed under this classification. There were a total of 14 such accidents, of which 5 were fatal, 5 resulted in disability of more than 10 days' duration and 4 in disability of 10 days or less duration. Passing, looking on and working near is here again the most important exposure with a total of 6 accidents, of which 2 are fatal, followed by repairing and testing with a total of 4 accidents, 2 of which were fatal. Shifting or applying belt resulted in 2 accidents, one of which was fatal, and oiling and cleaning, and repairing and testing each resulted in one accident.

Part of Transmission	*All Exposures*					*Operating Machine*			
	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—
All Parts	33	4	119	37	193	..	..	3	3
1. Shafts Smooth Between Bearings	27	4	94	31	156	..	..	1	3
2. Shafts, Collars and Couplings	5	..	5	4	14	..	..	1	..
3. Shaft Projections, Set Screws, Keys, Bolts	1	..	10	..	11	..	..	..	..
4. Shaft Ends	..	..	2	2	4	..	..	..	..
5. Clutches	..	..	6	..	6	..	..	1	..
6. Not Otherwise Classified	..	..	2	..	2	..	..	..	..

F. & P. T. D. = Fatal and permanent total disability.
P. D. = Permanent disability.
10+ = Disability of more than 10 days' duration.
10— = Disability of 10 days or less duration.

TABLE XII

SHAFT ACCIDENTS IN PENNSYLVANIA—JANUARY 1, 1920, TO
BY PART OF TRANSMISSION AND EXPOSUR

	Repairing and Testing					*Shifting or Applying Belt*					C
Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.
6	7	1	31	2	41	5	1	14	6	26	5
4	5	1 Arm	24	2	32	4	1 Arm	10	5	20	5
1	2	..	2	..	4	1	..	..	1	2	..
..	..	..	2	..	2	..	..	3	..	3	..
..	..	..	..	..	..	..	..	..	..	..	..
1	..	..	2	..	2	..	..	1	..	1	..
..	..	..	1	..	1	..	..	..	..	..	..

Cleaning			*Applying Belt Dressing*					*Passing, Looking On, Working Near*					*Not Otherwise Classified*				
0+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total
18	2	25	1	..	..	..	1	15	1	46	20	81	..	1	7	4	12
13	1	19	1	..	..	..	1	12	1 Leg	41	16	70	..	1 Arm	5	4	10
..	1	1	..	..	..	..	..	2	..	2	2	6	..	..	..	..	..
5	..	5	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	1	2	3	..	..	1	..	1
..	..	..	..	..	..	..	..	..	..	2	..	2	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1

Shaft Projection—Setscrews—Keys and Bolts

All accidents in which shaft projections of any kind were involved, were placed under this classification. In the period studied, there were only 11 accidents of this kind, one of which was fatal and 10 resulted in more than 10 days' disability. The fatal accident occurred under the exposure, passing, looking on or working near, while 5 accidents occurred in connection with oiling machine, and 3 in connection with shifting or applying belt.

Shaft Ends

All accidents resulting from revolving protruding shaft ends were placed in this classification. There were only a total of 4 accidents resulting from contact with this part of the transmission apparatus, two of which resulted in disability of more than 10 days and two in disability of 10 days or less.

Clutches

All accidents resulting in any manner from clutches were placed under this classification. These accidents usually resulted from coming into contact with the protruding fingers of old type clutches. Since comparatively few such clutches are now used, it is not surprising that only 6 accidents resulted, all causing disability of more than ten days.

Not Otherwise Classified

Two shaft accidents resulted from such unusual and peculiar conditions that they could not be properly classified.

Causes by Industry

Table *XIII* is a tabulation of shaft accidents over the period studied by industry. The metal and metal products industry, as is to be expected, leads in the number of shaft accidents. As in the case of belts and pulleys, the Clay,

Glass and Stone industries are again out of line with the other industries in the number of fatal accidents compared with the total of shaft accidents in these industries. The average percentage of fatal accidents in all industries in connection with shafts and shaft equipment is 15.3. The Clay, Glass and Stone industries have a percentage of 33⅓. Quarries and Mines are also out of line with the percentage of fatal shaft accidents at 40.

The high percentage of fatal transmission accidents occurring in the above industries can be accounted for partly by the fact that these industries are often located in isolated sections of the country, are seldom inspected by the State or insurance companies and often employ an unskilled type of labor. There is very little done in most of such industries to protect the employees against accidents.

Causes by Occupation of Injured

Table *XIV* is an analysis of the occupations of the injured persons in connection with shaft and shaft equipment accidents. The significant feature in this case, as in the case of belts and pulleys is that the machine operator leads with a total of 75 accidents out of 193. The repairman and

TABLE XIV

Analysis of Shaft Accidents by Occupation
January 1, 1920, to July 1, 1925

Occupation	No. of Accidents
1. Millwright	21
2. Millwright's Helper	..
3. Machinist	12
4. Machine Operator	75
5. Repairman and Oiler	27
6. Laborer	22
7. Helper	15
8. Engineer	8
9. Superintendent	..
10. Foreman	3
11. Not Otherwise Classified	10
	193

GEAR ACCIDENTS IN PENNSY

BY PART OF T

Part of Transmission	*All Exposures*					*Operating Machine*					*Repairing and Testing*					*Shifting o*	
	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.	10+	10—	Total	F. & P.T.D.	P.D.
Caught Between Gears	4	9	38	6	57	..	1 Hand	9	4	14	1	1 Hand 1 Arm	7	2	12	..	..

F. & P. T. D.
= Fatal and permanent total disability.

P. D.
= Permanent disability.

10+
= More than 10 davs disability.

10—
= Ten days or less disability.

TABLE XV

VANIA—JANUARY 1, 1920, TO JULY 1, 1925

ANSMISSION AND EXPOSURE

Applying Belt			*Oiling and Cleaning*					*Applying Belt Dressing*					*Passing, Looking On, Working Near*					*Not Otherwise Classified*				
10+	10—	Total	F. & P.T.D.	P.D.		10+	10—	Total	F. & P.T.D.	P.D.		10+	10—	Total	F. & P.T.D.	P.D.		10+	10—	Total	F. & P.T.D.	P.D.		10+	10—	Total
..	..	..	1	4	Hands	7	..	12	..	..		..	..	..	2	2	Hands	13	..	17	..	..		2	..	2

oiler, the millwright and the laborer also are seriously exposed to this hazard.

Table XIV shows that there is scarcely a person in the shop who is not exposed to shaft accidents. This should not be the case, as shafts, as has already been shown, are particularly dangerous from an accident viewpoint and machine operators and others should let repairs, oiling and adjustment of such equipment, to persons trained in that work.

Gears

Causes by Part of Transmission and Exposure

Table *XV* is an analysis of accidents over the period studied in connection with transmission gears, showing the part of transmission involved in the accident and the exposure.

Caught Between Gears

All accidents in connection with gears result in the injured being caught between gears. There were a total of 57 such accidents during the period studied, 4 being fatal, 9 permanent disabilities, 38 resulting in disability of more than 10 days and 6 resulting in disability of 10 days or less.

The exposure, passing, looking on or working near caused the largest number of accidents, having 17 of the total. Operating machine was an exposure resulting in 14 accidents while oiling and cleaning, and repairing and testing each resulted in 12 accidents. There were two accidents which could not correctly be classified under any of the exposures used. Gears are probably the best guarded of all transmission equipment and result in relatively few accidents, although the accidents which do occur are usually very serious.

Causes by Industry

Table *XVI* is an analysis of gear accidents by industry for the period studied. The significant feature of this table

is that 9 out of the classification of 20 industries had no transmission gear accident over the entire period studied. Approximately one-third of the gear accidents occurred in the Metal and Metal Products Industries where there are of course a great number of gears. The Clay, Glass and Stone Industries again appear unfavorably in the number of accidents.

Causes by Occupation of Injured

Table *XVII* is an analysis of the occupations of persons injured or killed as a result of gear accidents during the period studied. This table, like the two which preceded it, again shows that the machine operator is the person most often injured as a result of gear accidents. This fact is of value in making plans for accident prevention.

TABLE XVII

Analysis of Gear Accidents by Occupations

January 1, 1920, to July 1, 1925

Occupation	No. of Accidents
1. Millwright	2
2. Millwright's Helper	..
3. Machinist	1
4. Machine Operator	27
5. Repairman and Oiler	10
6. Laborer	7
7. Helper	6
8. Engineer	2
9. Superintendent	..
10. Foreman	1
11. Not Otherwise Classified	1
	57

TABLE XVI

GEAR ACCIDENTS BY INDUSTRIES—JANUARY 1, 1920, TO JULY 1, 1925

Industry	1920				1921				1922				1923				1924				1925 (6 Mos.)				TOTAL			
	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.	F	10+	10—	Ttl.
1. Building and Contracting	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	1	..	1
2. Chemical and Allied Products	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
3. Clay, Glass and Stone	..	3	..	3	1	1	..	2	..	1	..	1	..	7	..	7	..	1	..	1	..	..	..	..	1	13	..	14
4. Clothing Manufacture	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
5. Food and Kindred Products	..	3	..	3	..	1	..	1	..	..	..	..	..	2	1	3	..	..	..	..	..	..	..	..	..	6	1	7
6. Leather, Rubber Composition	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
7. Liquors and Beverages	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8. Lumber and Its Remanufacture	..	..	..	..	..	1	..	1	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	2	..	2
9. Paper and Printing	..	1	..	1	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	2	..	2
10. Textiles	..	..	..	..	..	1	..	1	..	2	..	2	..	4	2	6	..	..	..	..	..	..	..	..	..	7	2	9
11. Laundries	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
12. Metals and Metal Products	..	3	..	3	..	1	..	1	..	1	..	1	1	9	1	11	1	..	1	2	..	..	..	..	2	14	2	18
13. Transportation and Public Utilities	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
14. Quarries and Mines (Not Coal)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15. Tobacco and Its Products	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16. Miscellaneous Ind.	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
17. Hotels and Restaurants	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18. Mercantile Establishments	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
19. Jobbers and Warehouses	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20. Municipalities	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL	1	12	..	13	1	5	..	6	..	4	1	5	1	25	4	30	1	1	1	3	..	..	..	..	4	47	6	57

F = Fatal.
10+ = More than ten days' disability.
10— = Ten days or less disability.
Ttl. = Total.

| | | |

CHAPTER III

The Causes of Mechanical Power Transmission Accidents in Relation to the Existing Mechanical Power Transmission Code of Pennsylvania.

The classification of parts of transmission and exposures which is used throughout this study was developed after a careful analysis of all the information pertaining to the accidents covered had been made. The classification of parts of transmission contains all parts of transmission involved in the accidents studied and the classification of exposures contains the exposures resulting in the accidents studied. A safety code covering a particular type of equipment should provide both mechanical safeguards and safe practice regulations. The mechanical safeguards have to do with the proper guarding of the hazardous parts of the equipment; the safe practice regulations have to do primarily with the exercise of proper care where working with, handling, or being otherwise exposed to the dangers of the equipment. In ascertaining whether or not the existing standards for the guarding of mechanical power transmission equipment of the Commonwealth of Pennsylvania cover the existing hazards, the various parts of transmission in connection with which accidents have occurred during the period studied will be first considered, after which the exposure resulting in the accidents will be discussed from the viewpoint of the existing code.

Belts and Pulleys

Analysis by Part of Transmission

Pinch Point of Belt and Pulley

The most hazardous point of both belt and pulley is the point at which the belt runs onto the pulley, sometimes

called the "pinch point" or the "run-in-point." One half of the total of all belt and pulley accidents occur at this point. In examining Rule 76 (a) and Rule 77, of the present standards (Appendix F), we find that this point has been provided for inasmuch as all pulleys and all belts within six feet of the floor or working platform must be guarded (excepting the belt need not be guarded if it is one inch (1″) or less in width, or one-half inch (½″) or less in diameter, with a speed of less than twelve hundred (1200′) linear feet per minute. This means that in every case the pinch point must be guarded and in addition, the whole belt and pulley enclosed to a height of six feet (except in the case mentioned above when the pulley alone must be guarded). If the standards provide adequately for the guarding of the hazardous point, it would appear that these accidents must occur when no guard has been provided. This is not a justifiable conclusion as will be seen later under a discussion of exposure.

Contact With Moving Belt

Direct physical contact with the moving belt resulted in a total of 125 accidents. Reference to Rule 77 (c) of the existing standards (Appendix F) shows that all vertical or inclosed belts six feet or less above the floor or working platform must be guarded excepting belts one inch (1″) or less in width or one-half inch (½″) or less in diameter with a speed of less than twelve hundred (1200′) linear feet per minute. As the exception is a reasonable one if the belt is not laced with metal, it would appear that the existing provision in the code should have prevented these accidents.

Belt Other Than Direct Physical Contact

As was previously mentioned, accidents in this classification result indirectly from the belt, as in the case of a worker using a poorly adapted stick or pole to place the

belt on the upper pulley, which stick or pole becomes caught between belt and pulley or in the pulley. This type of accident can only be eliminated by the use of the proper type of belt pole and having the worker properly instructed in the method to be followed. There is no provision in the existing code to take care of this hazard.

Belt Breaking—Struck By End

There were a total of 92 accidents out of 1136 which resulted from this cause. This condition can be remedied primarily by proper maintenance and inspection of belts which should result in remedying the condition before the accident could arise. Rule 85 of the present standards provides for proper inspection but this rule should be made more specific so that it would order the condition liable to cause a break in the belt remedied as soon as ascertained. The guarding of belts both horizontal and vertical also is of some value in preventing accidents of this character, and the present standard in Rule 77 provides for such guarding. Such guarding is not nearly as effective for the prevention of this type of accident, as proper inspection and maintenance, as guards are not sufficiently strong to do much more than break the force of a flying belt and the dangling end of the belt extending beyond the guard is still able to cause an eye accident.

Belt Lacing

Of the total of 1136 belt and pulley accidents, 73 were caused by belt lacing, and in 10 other accidents belt lacing was definitely involved as a cause. The larger percentage of these accidents are caused by metal belt lacing, a raw hide lacing seldom causing an injury unless it be on a broken belt. A further study was made of belt lacing accidents and it was found that all the popular commercial brands were involved in the accidents studied. Metal lacing is a real hazard wherever it is at all possible that a person may

come in contact with it. The present standards aim to eliminate contact by requiring the belt to be guarded to the height of six (6) feet, Rule 77 (c) (d) (e) and by forbidding the use of metal lacing wherever belts are shifted by hand. Rule 77 (g).

Belt Winding on Shafting

There is nothing in the present mechanical power transmission standards which aims to prevent accidents resulting from belt winding on shafting.

Belt Running Off Pulley

In this classification were placed only those accidents where the pulley was so placed that it was possible for the whole belt to fall from the pulley to the floor. This of course would be the case with over hung pulleys. The present regulations in Rule 76 (c) provides for a guard so that this cannot occur. Therefore, in cases where such an accident has occurred in the past, the provisions of the code were not being carried out.

Caught By Pulley

In this classification were placed all accidents in which the injured was either caught by the spokes of the pulley or cut by the pulley. Rule 76 (a) and 76 (b) adequately provide for all such cases, by requiring pulleys six (6′) feet or less above the floor or working platform to be guarded and by providing that "where the bearings are not self-oiling and the clearance between the pulleys and the bearing on line and jack shafting is eighteen (18″) inches or less, pulleys over six (6″) inches in diameter shall be completely guarded on the side nearest the bearing, and keyways in the shaft between such pulley and bearing shall be properly filled or the shaft encased."

Chains and Sprockets

There were 41 accidents due to chains and sprockets out of a total of 1136. Rule 77 of the existing mechanical power transmission regulations provides adequately for the guarding of chains using the same provisions as for belts and ropes.

Ropes, Cables, Sheaves and Drums

This type of equipment is not used very widely for mechanical power transmission purposes, using the term mechanical power transmission as it has been previously defined in this study. There were only 7 accidents resulting from this type of equipment over the five and one-half year period studied. Ropes are provided for adequately in the existing regulations under Rule 77. Sheaves, cables and drums are not specifically provided for in the existing regulations, but it is the practice throughout the State to require them to be guarded in the same manner as belts and pulleys.

From the foregoing analysis of the present mechanical power transmission code it appears that from the standpoint of providing protection for the points of danger of belts and pulleys, that *in general* sufficient safeguards have been provided. There are a few exceptions to this rule. These exceptions have already been noted and will be discussed at greater length later. It seems surprising therefore, that if practically all the hazardous points have been provided for that such a large number of accidents should continue to occur. There are two possible explanations for the condition, namely: (1) either the present standards are not being enforced or (2) if enforced there is something radically wrong with the standards from a practical operating point of view. An analysis of the exposure which resulted in these accidents will be enlightening.

Analysis of Exposure of Belt and Pulley Accidents

Shifting or Applying Belt

From the viewpoint of the number of accidents as well as the degree of seriousness of the accidents involved, those occurring while the injured was shifting or applying belt are by far the most important. Of the total of 1136 accidents resulting from all exposures, 491 resulted from the exposure under discussion; 437 of which resulted from hand shifting or applying of belt, leaving only 54 accidents in which a shifter or a pole or stick of some kind were used to do the work. It is obvious that where a belt is being shifted or applied by hand any guard which may have been provided under existing standards must have either been opened or entirely removed to permit this being done. It is also obvious that an open guard or one that has been provided but has been removed is equivalent to no guard at all, and affords absolutely no protection. With the type of guards provided in existing standards there is no way in which a belt can be applied or shifted by hand without opening or removing the guards and exposing one's self to the hazards against which the guards have been provided as a protection. This seems to indicate the necessity for the use of belt shifters on all machines where the hand is now being used. Belt shifters make it possible to shift belts without removing the guards. The existing mechanical power transmission standards provide in Rule 82 (a) for mechanical belt shifters only where tight and loose pulleys are used.

The part of transmisson most important in connection with shifting or applying belt is the pinch-point of the belt and pulley. Three hundred and five of the 491 accidents under this exposure having occurred at this point, all but 8 having happened while the hand was being used to shift or apply the belt. Fifty-four of the total of 491 accidents of the exposure, shifting or applying belt, were accidents in

which either a shifter, or a pole or stick of some kind were used. A study of these 54 accidents shows the danger of using a poorly adapted belt pole or a stick. Six of the 14 fatal accidents were the result of following the above practice. The existing standards do not provide for the use of a particular type of safe belt pole. If this were done and the persons involved given the proper instructions in its use, accidents from this cause could be practically eliminated.

Where a guard cannot be used the worker is immediately exposed to all the hazards of the unguarded parts of the transmission, and consequently some accidents will occur in connection with all the unguarded parts as reference to Table *IX* will show.

Operating Machine

The next most important exposure from the standpoint of number of accidents involved is that of "operating machine." A total of 148 accidents happened from this exposure. It is evident that no guard was provided where the persons were caught between belt and pulley, where they came in contact with moving belt, either directly or indirectly, where belt lacing is involved, where injured was caught by pulley, where belt ran off pulley, or where chains and sprockets or ropes, cables, sheaves and drums are involved. The present standards, although as previously stated, provide guards, it appears that these guards were not being used at the time of the accidents. In cases of the remaining accidents, those in which the injured was struck by flying belt, might have been prevented or their severity might have been reduced by an adequate guard, although a guard in itself is no assurance against such accidents. In the cases in which the belt wound around shafting while operating machine, the presence or absence of a specific guard is not involved so much as whether or not the shaft was smooth, or whether or not there was sufficient distance

between pulley and hanger, or other part of shaft equipment involved, so that if the belt should come off of the pulley it could not be caught between pulley and hanger. There is nothing in the existing standards to provide a smooth shaft or proper distance between pulley and hanger.

Applying Belt Dressing

One hundred twenty-eight accidents occurred while the injured was applying belt dressing. This is again a type of accident which occurs when the guards have been removed, as belt dressing cannot be applied while the guards are in place. These accidents also occur while the machinery is in motion. In 90 of these accidents the injured was caught between belt and pulley. These accidents, of course, resulted from applying the belt dressing to the side of the belt running over the pulley, rather than to the belt as it comes off the pulley. As in the case of the exposure "operating machine" as soon as the guards are removed the hazards of all parts of the transmission equipment are present.

Passing, Looking On, Working Near

One hundred twenty-six accidents resulted from this exposure, many of which could, without doubt, have been prevented had proper guards been provided as required in the existing State Code. Of all the parts of transmission involved the only accident which guards, according to existing standards, would not have entirely prevented are those involving broken belts and belt winding on shafting.

Repairing and Testing

This is another exposure where guards are removed and accidents result. One hundred twelve accidents fall under this exposure. As all guards are usually removed while the equipment is being repaired and tested, the hazards of all

the equipment are exposed with the usual resulting accidents.

Oiling and Cleaning

This is also an exposure where guards are removed. This under present standards is necessary. One hundred nine accidents happened under this exposure, 59 or more than one-half of which resulted in the injured being caught between belt and pulley. The remaining accidents are scattered among other dangerous parts of the transmission equipment.

Not Otherwise Classified

Twenty-two accidents have been placed in this classification because the conditions under which they occurred were so unusual that they could not be otherwise classified.

Shafts

In making a study of shaft and shaft equipment accidents, one is impressed by the high percentage of fatalities, namely, 15.3. This high percentage of fatalities indicates the great hazards involved in the use and care of such equipment and immediately directs one's attention to whether or not the existing State regulations provide adequately for the guarding of hazardous points. This will be ascertained by a consideration of the parts of transmission involved in shaft accidents, and a study of the existing standards to determine whether the parts involved are required to be guarded.

Analysis by Part of Transmission

Shafts—Smooth Between Bearings

Of a total of 193 shaft accidents, 156 occurred in connection with the smooth shaft. By smooth shaft is meant that the accident resulted from the shaft, and not from shaft

equipment such as collars, coupling, clutches, set screws, etc. By referring to the existing standards of the State we find that Rule 75 (a) provides for the guarding of such shafts six feet or less above the floor or working platform. As a very conservative estimate would place 95% of the actual transmission shafts higher than six feet, comparatively few of such shafts have to be guarded. As shafts more than six feet above the floor or working platform should not be, because of their height, subject to hazardous contact by the worker it would seem that the present regulations are adequate.

Collars and Couplings

Accidents result from collars and couplings primarily because of protruding parts of such equipment. Fourteen of a total of 193 shaft accidents involved collars and couplings. As collars and couplings are shaft equipment that may require attention from the worker regardless of the height at which they are located, such collars and couplings should be guarded or made safe regardless of where they are located. This the present State regulations provide in Rule 80 (a) and in Rule 79 (a).

Shaft Projections, Setscrews, Keys, Bolts

Eleven accidents resulted from this cause over the period studied. The present regulations adequately provide for the guarding of such projections wherever located in Rule 81 (a).

Clutches

Only six accidents occurred from the use of dangerous clutches. Clutches are dangerous when they are of the type containing protruding parts. Rule 79 (a) of the present regulations adequately provides for this hazard by requiring that, no matter where located, clutches be of the safety type, or if not of the safety type that they be guarded.

Shaft Ends

Four accidents resulted from protruding shaft ends. This hazard is taken care of in the existing regulations in Rule 75 (b).

Not Otherwise Classified

Two accidents resulted from such peculiar and unusual circumstances that they could not be properly classified under the existing classification.

From the above analysis of the existing standards of the State it would appear that the present regulations adequately provide for the reasonable guarding of the dangerous points of shafts and shaft equipment. If this is so it is surprising to find so many accidents in connection with this equipment, especially where the smooth shaft is involved. Why these accidents occur can be clearly seen from an analysis of the exposures involved.

Analysis of Exposures

In making an analysis of exposures in connection with shaft accidents, one must bear in mind that by far the largest percentage of shaft accidents are in connection with overhead shafts. This is proven by observation in any factory, and by the very small number of 4 shaft accidents, which occurred while the injured was operating machine.* Since shafts and shaft equipment are largely overhead, the only time dangerous contact is possible is when for some special reason a worker will expose himself. Such a special reason would be oiling and cleaning, repairing and testing, shifting and applying belt or working near such shafts as would be the case while painting the ceiling. In such cases accidents would not be prevented by guarding the equipment, as any guards that might be used would necessarily have to be removed to perform the work, requiring the

*Thirty-four accidents occurred on shafts less than 6 feet in height.

worker to expose himself. The remedy for the prevention of these accidents is not additional guards but a series of safe practice regulations, among which should be included a rule that no one should go near such equipment while it is in motion, that all work requiring exposure to unguarded shaft equipment should be done only when the power has been shut off and provision has been made that it will not be turned on during the exposure.

Gears

The gears considered here are transmission gears, as defined earlier in this study. There were a total of 57 such gear accidents, in all of which cases the injured was caught between gears. Rule 78 of the existing mechanical power transmission code of the State adequately provides for this hazard by requiring that, "toothed, sprocket and friction gears, where exposed to hazardous contact, shall have a band guard with side flange extending inward to the root of the teeth on both sides, or shall be completely enclosed. Where there is a spoke hazard in conjunction with the use of the band guard with side flanges, the spokes shall be guarded."

In analyzing the exposure involved in these accidents it is found that 14 occurred while injured was operating the machine and 17 while injured was passing, looking on and working near, making a total of 31 accidents in which apparently no guard was provided, or if provided was not used. In 24 of the cases a guard if provided could not have been used because the exposure involved repairing and testing, or oiling and cleaning. In two cases the accident was the result of a very unusual combination of circumstances, which could not properly be classified under the existing classification.

The total number of gear accidents is so very low because there are relatively few transmission gears, and transmission gears have the reputation, justly earned, of being

very dangerous. One will often find them guarded in a factory that has neglected all other types of guarding.

Summary

If setting up stringent regulations for the guarding of mechanical power transmission equipment, and the actual guarding of such equipment according to such regulations could in themselves prevent mechanical power transmission accidents, Pennsylvania would be well provided for. However, the previous analysis has shown that a large percentage of the accidents occur when the present guards cannot be used, at such times when repairing, oiling, etc., are being carried on. There are two possible ways in which this type of accident can be reduced, namely: (1) by improved design of guards, and (2) by providing a series of safe practice regulations, observance of which on the part of the worker would absolutely prevent such accidents.

CHAPTER IV

Conclusions

Recommendations for Changes in, and Additions to, the Existing Mechanical Power Transmission Standards of the Commonwealth of Pennsylvania.

In view of the study made in previous sections of this report of the causes of mechanical power transmission accidents, and the relationship of these causes to the existing standards for the guarding this type of equipment, it now becomes possible to make certain definite recommendations for changes in, and additions to, the existing Standards. In making these recommendations the general classification of transmission equipment into belts and pulleys, shafts, and gears used throughout this study will be used.

Belts and Pulleys

The Elimination of Six-foot Belt Guards Under Certain Conditions.

Among others, two of the outstanding features of Table *IX* are the large number of accidents in which the injured was caught between the belt and pulley and the relatively few accidents resulting from direct physical contact with belt. Fifty per cent. or 568 of all the belt and pulley accidents resulted from the former cause, whereas, only 125 or slightly over 10% resulted from the latter cause. It seems to be the general impression that all moving vertical belts are extremely dangerous, and require protection up to the height of six feet. A detailed analysis of the exposures

involved in "contact with moving belt" accidents indicates that as was stated before, a guard is of no value under such exposures as "repairing and testing," "shifting or applying belt," "oiling or cleaning" and "applying belt dressing," as guards must be opened or removed when such work is being done. Eliminating such accidents from the total of 125, 39 accidents remain, 21 of which occurred while injured was operating the machine and 18 of which occurred under the exposure passing, looking on or working near. In these 39 accidents it would at first appear as though through the provision of a guard these accidents could have been prevented. A further analysis of these 39 accidents from the standpoint of the nature of the injury involved and the nature of the disability indicate the following:

TABLE VIII

ANALYSIS OF BELT ACCIDENT INJURIES

Nature of Injury	10+	10—	Total
Burn	2	3	5
Laceration or Cut	14	6	20
Bruise	2	4	6
Not Mentioned	2	6	8
	20	19	39

10+ = More than ten days' disability.
10— = Ten days or less disability.

It will be noticed that there are 20 cases of lacerations or cuts or more than 50% of the total. It is difficult to understand how a person coming into contact with a moving belt can be lacerated unless such belt is fastened with metal laces. Although the accident reports do not specifically state that metal laces were used, from the nature of the injury that is the only inference that can be drawn in these cases.

Experience teaches that coming into contact with a moving belt which is not laced with metal always causes a burn or a bruise. A person coming into contact with a

moving belt will instinctively pull his hand or arm away from the belt and the contact will not be for more than an instant. If he has not been caught by metal laces in the belt, a burn or a bruise alone will be the result. If caught by the metal laces a laceration or cut will be the result. Of the 19 accidents remaining, after eliminating the 20 cases of lacerations, 6 resulted in disability of more than 10 days and 13 in disability of 10 days or less. If in a period of 5½ years there are only 19 accidents caused by the failure to guard belts to the height of six feet when the metal laces of the belts have been removed the question immediately arises of whether it is necessary or even desirable to guard such belts. Before this question can be answered one must consider, (1) the effect in the past of the enforcement of the present standards in preventing these contact accidents, and (2) whether or not the removal of metal laces, and the effective guarding of belt at the run-in or nip-point of the pulley, would not in the long run result in fewer accidents, and more general guarding of hazards which actually exist.

It is impossible to make any positive statement as to the effect that present standards have had in keeping "contact with moving belt" accidents at a very low point. It is admitted that transmission equipment is on the whole the best guarded type of equipment. However, in comparing two groups of industries, the metal and metal products group, which is undoubtedly the best guarded group and which has always used the six-foot belt guard, with the textile group of industries which in Pennsylvania as a group have never installed six-foot belt guards, one finds that accidents resulting from coming into "contact with moving belt" while "operating machine" or "passing by, looking on or working near" are very scarce in both groups of industries. The textile industries having in the period studied but seven, two of which resulted in disability of more than ten days and the metal and metal products group having eleven, seven of which resulted in disability of more

than ten days. If the textile industry which has always permitted vertical belts to be unguarded, and which is an industry in which belt transmission is very widely used, and which employes large groups of unskilled workers, has had such a very small number of accidents in a period of five and one-half years, certainly six-foot vertical belt guards are unnecessary if the metal laces are removed. There are only two conditions under which six-foot belt guards are desirable, namely, when metal laces are used and when the speed of the belt is excessive. It should be insisted that metal laces be removed from belts, when belts are not guarded as such laces are a distinct hazard, as their points cause severe lacerations should some one come into contact with them. In a study made of accidents in which metal laces were involved it was found that practically all the popular commercial brands of metal laces were dangerous from an accident viewpoint.

Shifters

The large number of accidents resulting from hand shifting or applying belt and from the use of belt poles in removing or applying belts warrants the recommendation that belt shifters be required in all cases where the hand is now used in shifting the belt. Of the 491 accidents which occurred while shifting or applying belt 437 resulted from hand shifting or applying of belt.

Six fatal accidents and a total of 53 non-fatal accidents resulted from the use of a poorly adopted stick or pole in removing from or applying the belt to an overhead pulley. The necessity for this practice will be reduced to a minimum by the use of shifters, but there will always be cases where the belt will run off the pulley, and this method will have to be used. These accidents warrant the recommendation that every shop be equipped with a belt pole adapted to the work it is to do, and that that pole, and that pole alone, be used and not any piece of wood that happens to be handy.

It would be well to include in a series of safe practice regulation that this work be done by some one properly instructed person in the shop and not by all the workers.

Nip-point of Belt and Pulley

The large number of accidents, 50% of the total, resulting from the injured being caught between belt and pulley warrants the recommendation that the nip-point be adequately guarded.

If the nip-point is adequately guarded, and this can be done by properly enclosing the pulley and supplying shifters, and if the six-foot belt guards are removed, a tremendous reduction of accidents will result. Under such conditions the hazardous work of repairing and testing, oiling and cleaning and applying belt dressing, which in the past has always been done with the guards removed, will in most cases now be done with the guards in place, eliminating therefore the hazards involved in this work.

Belt Perches

The accidents due to the belt winding on shafting are the result of permitting idle belts to rest on revolving shafts. These shafts are not always smooth and the belts sometimes begin winding around the shaft, often pulling machinery over with them. In order to eliminate this hazard where loose pulleys are not used, belt perches should be provided in order to prevent idle belts from coming into contact with the shaft. These perches should be of a type which permits the easy shipping of belts to and from them.

Belt Guide

Where a pulley is so located that the distance to the nearest fixed pulley, clutch or hanger is less than the width of the belt it carries, a belt guide should be provided on the side where there is insufficient clearance. Failure to provide such a guide presents a very serious accident

hazard, as the belt becoming caught between the pulley and the obstruction will rapidly wind up, pulling the machine over. Sometimes workers will attempt to prevent this winding by pulling on the belt. This is an extremely dangerous thing to do, and usually results in serious accidents.

Safe Practice Regulations

A series of safe practice regulations in connection with the use, care and maintenance of belts and pulleys is one of the most important needs. These safe practice regulations should be included in the published standards applying to mechanical power transmission equipment.

Shafts

A careful consideration of shaft accidents in their relation to the existing standards of the State for the guarding of this equipment, shows that the existing standards are adequate. Careful observance of present guarding standards by the employer, in addition to the use of safe practice methods by the employee, will practically eliminate shaft accidents. The importance of safe practice methods cannot be overemphasized.

Gears

In this study transmission gears, according to the definition of transmission used in the present State standards, alone have been considered and machine gears are not included. There are comparatively few transmission gears compared with the vast number of machine gears, and this accounts for the very few transmission gear accidents which occurred during the period studied. If the present definition of transmission continues to be used, then the existing standards for the guarding of gears are adequate, and should be enforced. However, in addition to the existing standards, a series of safe practice regulations should be

issued, which, if followed by the worker, will eliminate all accidents that are the result of unsafe methods in connection with the repair, oiling, cleaning and testing of machinery. If at some future time machine gears are to come under the definition of transmission, then consideration should be given to the possibilities of the use of nip-point guards on such gears. Machine gears are often found to consist of a whole series of intermeshing gears, and when a single enclosing guard is used for this whole series, adjustment or repair to any set of gears involves opening the guard, exposing the nip-point of all of the other gears. If nip-point guards were used in such instances the guard of the set of gears involved could be removed without exposing the worker to the hazards of all the remaining gears. Moreover, the nip-point guard, because it does not collect dust like the fully enclosing guard, reduces the fire hazard. However, there is one serious disadvantage to the use of this guard, and that is that unless it is placed as close as possible, certainly one-quarter inch or less from the gear teeth, such a guard adds another hazardous point. Its use should be confined to small gears, and only when there is some positive arrangement that the guard will not be placed further than a quarter of an inch away from the teeth of the gear.

Safe Practice Instructions

Equally important as the provision of adequate physical guards for hazardous points, is the necessity for the use of safe practice methods in the use, maintenance and repair of mechanical power transmission equipment. One of the outstanding features of a study of the causes of mechanical power transmission accidents is the thoughtlessness and disregard for danger which many workers exhibit when working around such equipment, and the great waste of power on the part of the employer, resulting from the failure to properly maintain transmission equipment. This

lack of proper maintenance not only results in great power losses but also results in unsafe conditions, which lead to serious and sometimes fatal accidents to workers. If employers had a greater knowledge of belt economy, and put that knowledge to work to eliminate power losses, they would automatically reduce transmission accidents and save a considerable amount of money for themselves. However, as long as employers continue to choose haphazardly the types of belts required for their machines, as long as they pay no attention to the alignment of shafts, as long as they use the types of belt dressings which ruin belts rather than preserve them, and even worse permit workers to apply this dressing on the side of the belt running into the pulley, as long as every worker in the shop is permitted to do whatever he wishes to the belts, pulleys and other transmission equipment, instead of having this highly specialized work performed by some one especially trained for it, just so long will we continue to have transmission accidents, no matter how well the equipment is guarded. The handling, the care and the maintenance of transmisison equipment is a highly specialized piece of work and should be in the hands of some one in the shop with special training for it. That this is not so at the present time is seen from the previous analysis of the occupations of persons injured in transmission accidents. Such a person should be trained not only in the technical transmission economy, but he should be well grounded in safe practice methods.

Summary

The following statements summarize the recommendations made for the changes in, and additions to, the existing mechanical power transmission standards of the Commonwealth of Pennsylvania:

1. The existing requirements for a six-foot vertical belt guard is unnecessary if the metal laces of the belt are removed and the nip-point of the belt and pulley is

adequately protected. The only hazard involved in coming into contact with a vertical belt, not operating at excessive speed, is from the metal laces which the belt may contain. If the metal lacing is removed the hazard no longer exists.

2. The nip-point of belt and pulley should be so guarded that it will be impossible for the hand to be caught in it. This can be done in connection with guarding the pulley.

3. The hand shifting and applying of belt should be entirely eliminated by requiring shifters on all machines.

4. In such cases, where for some reason it becomes necessary to apply a belt to an overhead pulley , a properly constructed belt pole should be used instead of using any pole or stick which may be handy at the time.

5. Belt perches should be provided wherever an idle belt would otherwise be permitted to rest on a revolving shaft.

6. Belt guides should be used wherever it is possible for a belt to run off of its pulley, when the distance to the nearest fixed pulley, clutch or hanger is less than the width of the belt.

7. Present standards for the guarding of shafts are adequate.

8. Present standards for the guarding of gears are adequate.

9. Safe practice regulations should be issued, indicating the proper use and maintenance of mechanical power transmission equipment. These regulations should provide for frequent inspections by a competent person and should set forth in detail the methods to be followed in the handling and maintenance of the equipment.

APPENDICES

APPENDIX A

County..... Code..... No.....

STATE WORKMEN'S INSURANCE FUND
18-26 So. Fourth Street
Harrisburg, Penna.

DO NOT USE THIS BLANK FOR COAL MINE ACCIDENTS EITHER INSIDE OR OUTSIDE—IMPORTANT INFORMATION AND SUGGESTIONS—PLEASE READ

Under present arrangements it is no longer necessary for employers to forward a copy of each accident report to the Workmen's Compensation Bureau, Department of Labor and Industry, BUT ALL ACCIDENTS regardless of length of disability MUST BE REPORTED TO THE STATE WORKMEN'S INSURANCE FUND immediately, as we must have the report of accident before any payment can be made of medical cost or compensation.

PROMPTNESS HELPS OUR SERVICE TO YOU. Send your accident reports promptly.

SEND THIS COPY AND THE SECOND COPY TO THE STATE WORKMEN'S INSURANCE FUND, the third copy of the report is to be retained by you as your record of the accident.

EMPLOYER'S REPORT OF ACCIDENT TO EMPLOYE

Policy No.....

1. Name of Employer.....
   City or town.....
2. Office address: Street and No.....
3. Nature of business.....
4. Location of plant where accident occurred: Street and No.....
   City or town..... County.....
5. If accident occurred away from plant, state where.....
6. WERE ANY OTHER OF YOUR EMPLOYES INJURED IN THIS ACCIDENT..... If so, how many.....
7. Date of accident..... 8. Day of week..... 9. Hour of day.....
10. Hour injured person begun work that day.....
11. Date disability began..... 12. Working hours per day.....
13. Average working days per week.....
14. Name of injured employe.....
    Home address.....
15. Sex..... 16. Age..... 17. Speak English.....
18. Nationality and race.....
19. Single, married or widowed..... 20. No. of children under 16 years.....
21. If injured was paid by the day, hour or output, give daily wages or average earnings per day.....
22. Weekly wages, if not paid by the hour, day or output.....
23. Piece or time worker.....
24. Engaged in what work when injured.....
25. In what department or branch of work.....
26. Was this the regular occupation of injured person.....
27. KIND OF MACHINE, TOOL OR APPLIANCE IN CONNECTION WITH WHICH ACCIDENT OCCURRED.....
28. Hand feed or mechanical.....
29. Part of machine on which accident occurred.....
30. Length of experience at machine or operation.....
31. DESCRIBE IN FULL HOW ACCIDENT OCCURRED, STATING CAUSE CLEARLY.....
32. Was an approved safeguard in use at the time of the accident.....
33. Names and addresses of witnesses.....
34. Nature of injury as definitely as possible.....
35. Part of body injured..... (State whether left or right).....
36. Attending physician or hospital, name and address.....
37. Has employe returned to work..... 38. If so, when.....
39. If not, state your estimate of probable time loss due to accident.....
40. If injury resulted in death, give date.....
41. Name of undertaker..... 42. Address.....
43. Are dependents, if any, non-resident aliens.....
44. If so, give name and address of next kin in United States.....
45. Name of company carrying your compensation insurance STATE WORKMEN'S INSURANCE FUND.

Date of report..... Made out by.....

Form S. O. F.—39—10M—3-16-23

APPENDIX B

TRANSMISSION ACCIDENTS

Case Number	Industry and Employer	Occupation of Injured Person	Work at Time of Accident	Part of Transmission	Guards	Code Number	Manner of Occurrence															Length of Experience at Job or Operation	Nature of Injury	Length of Time Out	Description of Accident	Comments
							(1) Starting	(2) Adjusting	(3) Repairing and Testing	(4) Applying Belt Dressing	(5) Throwing Belt On or Off	(6) Oiling and Cleaning	(7) Operating Other Machine	(8) Working Near (Not 7)	(X) N. O. C.											

APPENDIX C

Existing Cause Classification of Mechanical Power Transmission Accidents

TRANSMISSION

Columns 1 and 2	*Column 3*	*Column 4*	*Column 5*
X2—Transmission	0—Shaft	0—Shaft Ends	0—
		1—Collars and Couplings	1—Starting
		2—Shaft Ends (Overhead)	2—Adjusting
		3—	3—Repairing and Testing
		4—	4—Applying Belt Dressing
		5—Set Screws, Key or Bolts	5—Throwing Belt On or Off
		6—	6—Oiling and Cleaning
		7—Clutch	7—Operating Other Machine
		8—	8—Working Near (Not 7)
		X—N. O. C.	X—N. O. C.
	1—Belts, Cables and Pulleys	0—Overhead	
		1—	
		2—Flying Belt Lacing	
		3—	
	2—	4—Breaking	
	3—Gears	5—	
	4—N. O. C.	6—Chains or Sprockets	
		X—N. O. C.	

APPENDIX D

Cause Classification of Mechanical Power Transmission Accidents Used in Study

BELTS AND PULLEYS

By Part of Transmission

1. Caught between belt and pulley.
2. Contact with moving belt—direct physical contact.
3. Contact with moving belt other than direct physical contact—e.g., shifting pole hits belt and pole hits worker in stomach.
4. Belt breaking—struck by flying end.
5. Belt lacing—not broken belt.
6. Belt winding on shifting.
7. Belt running off pulley.
8. Caught by pulley.
9. Chains and sprockets.
10. Ropes, cables, sheaves and drums.

By Exposure

1. Operating machine.
2. Repairing and testing.
3. Shifting or applying belt.
4. Oiling or cleaning.
5. Applying belt dressing.
6. Passing, looking on or working near.
7. Not otherwise classified.

SHAFTS

By Part of Transmission

1. Smooth shafts between bearings.
2. Collars and couplings.
3. Shaft projections, set screws, keys and bolts.
4. Shaft ends.
5. Clutches.
6. Not otherwise classified.

By Exposure

1. Operating machine.
2. Repairing and testing.
3. Shifting or applying belt.
4. Oiling or cleaning.
5. Applying belt dressing.
6. Passing, looking on or working near.

GEARS

By Part of Transmission

1. Caught between gears.

By Exposure

1. Operating machine.
2. Repairing and testing.
3. Shifting or applying belt.
4. Oiling or cleaning.
5. Applying belt dressing.
6. Passing, looking on or working near.
7. Not otherwise classified.

APPENDIX E

FATAL ACCIDENT INVESTIGATION REPORT

Report No.....
Date.....
District.....

Firm.....Address.....
Accident occurred at.....
Employe.....Address.....
Date of accident.....Date of death.....
Description of accident:
Witnesses:
Accident investigator's report:.....
.....
.....
.....
.....
.....

(Use back of sheet for any additional information)

Did the accident occur as stated above?.....
If not, what are your findings?.....
.....
.....
.....
Has this plant an efficient safety organization?.....
Who was responsible for this accident?.....
Was there any violation of law or of the Safety Standards of this Department?.....If so, state which.....
.....
Would you recommend prosecution?.....
If not, give reason.....
.....
What orders were issued to prevent a recurrence of a similar accident?
.....
.....
.....
Name of person interviewed.....
Date.....Instruction No.....Inspector.....

Supervising Inspector: Do you concur in Inspector's report? (Yes or No).....
Name.....Date.....

NOTE: When investigation is completed the original report, signed by the inspector, shall be returned by the supervisor to the Harrisburg office. One copy of the report may be retained by the supervisor and the other copy by the inspector. The object of an accident investigation is (a) to ascertain the facts so that the cause of the accident may be determined, (b) to place responsibility for accident, (c) to issue any orders which may be necessary to correct unsafe practices or conditions and thus prevent a recurrence of a similar accident.

Form No. IS—88

APPENDIX F

Volume 1 Number 3

Commonwealth of Pennsylvania
DEPARTMENT OF LABOR AND INDUSTRY
Clifford B. Connelley, Commissioner

SAFETY STANDARDS OF THE INDUSTRIAL BOARD

Mechanical Power Transmission
Rules 75 to 85 Inclusive

FOREWORD

This Safety Standard shall be understood:—

To pertain to MECHANICAL POWER TRANSMISSION as hereinafter defined;

To set forth the rules to safeguard the life and limb of workers in industries in which said MECHANICAL POWER TRANSMISSION is used;

To place the responsibility for compliance with the rules upon the employer and employe;

To prescribe a method of procedure for modifying or suspending any such rules, and

To provide a penalty for the violation of these rules.

It shall be understood further that the provisions of all other Standards issued by the Industrial Board shall apply in all matters not specifically covered by this Standard involving the life, limb and health of the worker.

Penalty

Every person or persons who violate any of the provisions of these rules of the Industrial Board, or who interfere with the Commissioner or his duly authorized representative in the enforcement of these rules, shall be deemed guilty of a misdemeanor, and may, upon conviction thereof, be punished by fine or imprisonment, or both.

Petition

For the modification or suspension of any of the attached rules the following shall be the method of procedure:

Any employer, employe or other person interested or

affected by these rules may petition for a hearing on the reasonableness of such rules by filing a petition with the Industrial Board, through its Secretary, setting forth the full details, the rule or rules upon which a change is desired and the reasons for said change;

Upon receipt of such petition the Industrial Board shall determine the merits of said petition by confirming without hearing its previous determination; or, if such hearing is necessary to determine the issue raised, the Industrial Board shall order a hearing thereon and consider the matter in question at such time as prescribed. Notice of time and place of such hearing shall be given to the petitioner and to such other persons as the Industrial Board may find directly interested in such decision.

MECHANICAL POWER TRANSMISSION

Section 1. Administration

The rules set forth in this Standard shall apply to every establishment within this Commonwealth.

(a) No person or persons shall remove or make ineffective any safeguard, safety appliance or device attached to machinery, except for the purpose of immediately making repairs or adjustments; and any person or persons who remove or make ineffective any such safeguard, safety appliance or device, for repairs or adjustments, shall replace the same immediately upon the completion of such repairs or adjustments.

(b) Every employer or person exercising direction or control over any person or persons who remove such safeguard, safety appliance or device, or over any person or persons for whose protection it is designed, shall have the safeguard, safety appliance or device so removed, promptly and properly replaced.

(c) Every employe shall use all safeguards, safety appliances or devices furnished for his protection and shall

be responsible for carrying out all Safety Standards which may concern or affect his conduct.

Section 2. Definitions

For the application of these rules:

(a) The term ESTABLISHMENT shall mean a place within this Commonwealth where work is done for compensation, to whomever payable, supervision over which has been given by statute to the Department of Labor and Industry.

(b) The term MECHANICAL POWER TRANSMISSION shall mean all revolving shafts, pulleys, sheaves, gears, wheels, rotating and reciprocating parts, moving belts and equipment from the prime mover up to but not including the machine driven, or any such parts of the machine that stop when the machine stops.

(c) The term STANDARD RAILING shall mean a railing not less than forty-two inches (42″) in height with an additional rail midway between the top rail and the floor or platform level, placed not less than fifteen inches (15″) or more than twenty inches (20″) from the point of hazardous contact.

(d) The term HAZARDOUS shall mean that the location of an object is so accessible as to permit of contact that may result in injury.

(e) The term GUARDED-ENCASED-ENCLOSED shall mean that the object is so covered, fenced or surrounded that contact, which may result in injury, at the point of danger is remote.

(f) The term DEPARTMENT shall mean the Department of Labor and Industry.

(g) The term BOARD shall mean the Industrial Board.

(h) The term COMMISSIONER shall mean the Commissioner of the Department of Labor and Industry.

(i) The term APPROVED shall mean approved by the Industrial Board.

Section 3. Specifications

(A-I) All installations
(E-I) Existing installations
(N-I) New installations

Rule 75. Shafting

(a) (A-I) Shafting located six feet (6′) or less above the floor or working platform shall be guarded.

(b) (A-I) Projecting shaft ends located six feet (6′) or less above the floor or working platform shall be cut off and the extending piece shall not exceed one and one-half inches (1½″) in length and shall be made smooth, or shall be completely encased with a stationary guard.

Rule 76. Pulleys

(a) (A-I) Pulley six feet (6′) or less above the floor or working platform shall be guarded.

(b) (A-I) Where the bearings are not self-oiling and the clearance between the pulley and the bearing on line and jack shafting is eighteen inches (18″) or less, pulleys over six inches (6″) in diameter shall be completely guarded on the side nearest the bearing, and keyways in the shaft between such pulley and bearing shall be properly filled or the shaft encased.

(c) (A-I) Overhung pulleys on ends of shafts shall be so guarded that a belt cannot run off a pulley and fall to the floor.

Rule 77. Belts, Ropes and Chains

(a) (A-I) All overhead rope, belt or chain drive guards shall be of sufficient width to provide an adequate and safe amount of space between the belt and drive they protect.

(b) (A-I) Passageways between the upper and lower parts of belts, ropes and chains are prohibited unless permission is granted by the Industrial Board.

(c) (A-I) Vertical and inclined belts, ropes and chains, six feet (6′) or less above the floor or working platform shall be guarded. [Belts one inch (1″) or less in width or one-half inch (½″) or less in diameter, with a speed of less than twelve hundred (1200) linear feet per minute, excepted.]

(d) (A-I) Where a horizontal belt, rope or chain is within six feet (6′) of the floor or working platform a guard shall be provided, which shall extend to at least fifteen inches (15″) above the belt or to a height of at least six feet (6′). In no case shall it be less than forty-two inches (42″) in height unless the belt is completely encased.

(e) (A-I) Overhead horizontal belts, ropes or chains more than six feet (6′) and less than seven feet (7′) above the floor or working platform shall be guarded on sides and bottom. Guards or standard railings around inclined belts shall be so installed that the vertical clearance between the lower run of the belt and the floor shall be not less than six feet (6′) at any point outside of the guard or railing.

(f) (A-I) Overhead horizontal belts, ropes or chains more than six feet (6′) above the floor or working platform, of six inches (6″) or more in width, located so that they endanger persons below in case of breakage, unless guarded in accordance with the preceding paragraph shall be guarded on sides and bottom in accordance with the following or its equivalent:

1. Guards shall extend to the wall or ceiling effectively enclosing the belt, rope or chain drive. Where they are so located, due to building construction, that it is impracticable to carry the guard to the wall or ceiling, the guard shall be constructed to form a complete enclosure around the belt, the top and bottom runs and the pulleys.

2. For belts ten inches (10″) or more in width up to and including fourteen inches (14″) in width, the frame shall be not less than one and one-half inch by one and one-half inch by one-quarter inch (1½″ x 1½″ x ¼″) angle iron, one at each side of the guard for its entire length, and the filling material shall be of three-sixteenth inch by one and one-half inch (3/16″ x 1½″) flat iron spaced two inches (2″) apart, and laid parallel with the side frame members. The parallel filler strips and the side frame members shall be held together by the use of cross members to be known as filler supports, which shall be of five-sixteenth inch by two inches (5/16″ x 2″) flats, riveted to the side frame angles with two (2) five-sixteenth inch (5/16″) rivets, and the filler supports shall be spaced at intervals of not more than twenty inches (20″) center to center.

3. Guards shall be supported to the wall or ceiling by supporting members spaced at intervals of approximately three feet (3′) and the supporting members shall be five-sixteenth inch by two inches (5/16″ x 2″) flat iron, riveted to the side frame angles with two (2) three-eighth inch (⅜″) rivets or bolted with two three-eighth inch (⅜″) bolts. Guards and all their supporting members shall be securely supported to the wall or ceiling by not less than one-half inch by three and one-half inch (½″ x 3½″) lag screws, into the floor beams or ceiling rafters, or by not less than one-half inch (½″) diameter bolts placed in a horizontal position through the floor beams or ceiling rafters. The use of thru-bolts for supporting the guard is preferable to the use of lag screws, and this method is to be considered mandatory where their use is practicable.

4. For belts in excess of fourteen inches (14″) in width, the guards shall be constructed similar to the foregoing specifications except that the sizes and dimensions as shown in the table appended to this Safety Standard shall be used. In guarding belts over twenty-four inches (24″) wide, angle iron instead of flat iron is required for filler supports. For

the three-sixteenth inch by one and one-half inch (3/16" x 1½") flat iron specified above for filling material, there may be substituted solid or perforated sheet metal of the sizes indicated in the table appended to this Safety Standard. (Woven wire mesh and expanded metal prohibited.)

5. Overhead rope and chain drive guards shall conform to the rules for overhead belt guard construction of similar width, except that the filler material shall be of solid construction as shown in the tables appended hereto, and a side guard member of the same solid filling material shall be carried up in a vertical position two inches (2") above the level of the lower run of the rope or chain drive and two inches (2") within the periphery of the pulleys which the guard protects, thus forming a trough. These side filler members shall be reinforced on the edges with one-fourth inch by one and one-half inch (¼" x 1½") flat iron riveted to the filling material at intervals of not more than eight inches (8") center to center; the reinforcing strip shall be riveted or bolted to all guard supporting members with at least one three-eighth inch (⅜") rivet or bolt at each intersection, and the ends shall be lagged or bolted to the ceiling with not less than one-half inch (½") lag screws or bolts. The filling material shall be secured to the framework of the guard and the filler supports by the use of three-sixteenth inch (3/16") rivets spaced not more than four inches (4") from center to center.

6. Where the distance between the two shafts is not in excess of fifteen feet (15') the spacing between the belt, rope or chain and the guard shall be six inches (6"). Where the distance is in excess of fifteen feet (15') and not in excess of twenty-five feet (25'), the spacing shall be ten inches (10"). Where the distance is in excess of twenty-five feet (25') and not in excess of forty feet (40'), the spacing shall be fifteen inches (15"). Where this distance is in excess of forty feet (40'), the spacing shall be twenty inches (20").

7. Suitable reinforcements shall be provided for the ceiling rafters or overhead floor beams where necessary to sustain safely the weight and stress likely to be imposed upon the guard. The interior surface of all guards, by which is meant the surface of the guard with which a broken belt will come in contact, shall be perfectly smooth and free from all projections of any character, except where construction demands, button head rivets may be used.

(g) (A-I) Belts shifted by hand shall not be laced with metal.

Rule 78. Gears

(a) (A-I) Toothed, sprocket and friction gears, where exposed to hazardous contact, shall have a band guard with side flange extending inward to the root of the teeth on both sides, or shall be completely enclosed. Where there is a spoke hazard in conjunction with the use of the band guard with side flanges the spokes shall be guarded.

Rule 79. Clutches and Couplings

(a) (N-I) Shaft couplings and clutches shall be of safety type with bolts and nuts countersunk, or protected by a flange.

(E-I) Couplings and clutches located seven feet (7′) or less above the floor or working platform, or where less than eighteen inches (18″) from a shaft bearing, if not guarded by standard railing, shall be encased.

Rule 80. Collars

(a) (N-I) Collars, including split collars and couplings, shall be cylindrical and screws or bolts shall not project beyond the largest periphery of the collar.

(E-I) Collars, including split collars and couplings, which are not of the cylindrical type and where screws or

bolts project beyond the largest periphery of the collar shall be encased.

Rule 81. Keys and Set Screws

(a) (A-I) Protruding keys, set screws or other projections in revolving parts shall be made flush or guarded. (Keys or set screws within gear or sprocket casings, or in hubs or pulleys twenty inches (20″) or less in diameter, where they are within the plane of the rim of the pulley, excepted.)

Rule 82. Shifters

(a) (A-I) Shifters with handles shall be provided for all tight and loose pulleys, clutches and starting gears. The shifter handle shall be located outside of the guard.

(b) (A-I) Where necessary to locate shifter handles over passageways the lower ends of the handles shall be at least six feet (6′) above the floor level.

(c) (A-I) All mechanical belt shifters shall be equipped with a positive locking device which shall be normally in the "off" position.

(d) (A-I) Shifters and disengaging levers when suspended overhead shall be so balanced and hung that by their own weight the belt will be kept on the loose pulley or the clutch or gear in the disengaged position.

(e) (A-I) Controls for stopping machines shall be so arranged that the operators can conveniently stop machinery from any operating position. The control shall be at a point outside of the guard.

Rule 83. Guards

(a) (A-I) The material and minimum dimensions for the framework of all guards shall be angle iron one-eighth inch by one inch by one inch (⅛″ x 1″ x 1″), iron pipe of three-quarter inch (¾″) inside diameter, or metal con-

struction of equivalent strength [except as specified in paragraph (b)].

(b) (N-I) Wood guards shall not be used except in woodworking shops, plants manufacturing or using explosives and in establishments where fumes or manufacturing processes would create objectionable or dangerous conditions. Where wood guards are exposed to acids or gaseous fumes they shall be treated with a preservative to prevent deterioration of the wood.

(c) (A-I) The frames of all guards fastened to the floor or working platform, and without other support or bracing, shall consist of not less than one-eighth inch by one and one-half inches by one and one-half inches (⅛″ x 1½″ x 1½″) angle iron, pipe of one and one-fourth inches (1¼″) inside diameter, or metal or wood construction of equivalent strength.

(d) (A-I) Guards having framework lighter than one-eighth inch by one and one-half inches by one and one-half inches (⅛″ x 1½″ x 1½″) angle iron, pipe of one and one-fourth inches (1¼″) inside diameter, or metal or wood construction of equivalent strength, shall be rigidly braced to some fixed part of the machinery or building structure, at least every three feet (3′) of their height.

(e) (A-I) Doors in guards shall be constructed of material at least one-half the strength specified above.

(f) (A-I) The fastening of all guards to the floor shall be efficiently and securely done and all corners shall be strongly braced.

(g) (A-I) The filling material shall be fastened to the supports by one of the following methods:

1. Angle iron supports: By means of not less than one-eighth inch by three-fourths inch (⅛″ x ¾″) flat iron strips fastened to the angle by three-sixteenth inch (3/16″) bolts or rivets placed at intervals not exceeding six inches (6″),

or by wooden strips one inch by one inch (1″ x 1″) bolted, or by other material of equivalent strength. Metal that is either perforated, expanded or solid, shall be bolted, riveted or welded directly to angle iron supports.

2. Pipe-supports—Clamped or held securely by heavy wire fastened on the inside of the guard.

(h) (A-I) There shall be no unsupported panels of guards of greater dimension than forty-two inches (42″).

NOTE: Guards less than thirty inches (30″) in height and not in excess of six square feet (6 sq. ft.) area, and having a framework of one-half inch (½″) solid rod, one-eighth inch by three-fourths inch by three-fourths inch (⅛″ x ¾″ x ¾″) angle, or equivalent thereof, may be constructed of the standard filling materials specified in the appended table.

Rule 84. Starting and Stopping of Machinery

(a) (A-I) Unless all machinery can be easily seen from its control station, effective signals shall be provided with which to give ample warning before starting machinery.

(b) (A-I) Emergency stops, properly marked and easily accessible, shall be provided in each room, section or department, by which each complete and separate unit of power transmission therein can be quickly stopped.

Rule 85. Inspection, Lubrication and Guarding of Moving Parts

(a) (A-I) Mechanical power transmission equipment including its guards shall be given careful inspection at frequent and regular intervals and records kept of conditions found.

(b) (A-I) Oiling shall be done only by authorized persons and all oilers shall wear a minimum of loose clothing. Drip cups and pans shall be securely fastened.

(c) (A-I) Crossheads, cranks, connecting rods, counterweights and similar rotating and reciprocating parts, which

present shearing or crushing hazards, shall be guarded or protected by standard railings.

CLIFFORD B. CONNELLEY, Chairman,

MRS. SAMUEL SEMPLE,

*A. L. GARVER,

OTTO T. MALLERY,

JAMES C. CRONIN,

FRED J. HARTMAN, Secretary,
Industrial Board.

*Deceased.

SPECIFICATIONS FOR STANDARD BELT GUARDS

Material	A. Clearance from Belt at all Points	B. Largest Mesh or opening Allowable	C. Minimum Gauge (U. S. Std.) or thickness	D. Min. Height of Guard from floor or Platform level
Woven wire	Under 4 in.	½ in.	No. 16	6 ft.-0 in.
	4 in. to 15 in.	2 in.	No. 12	5 ft.-0 in.
Expanded metal	Under 4 in.	½ in.	No. 18	6 ft.-0 in.
	4 in. to 15 in.	2 in.	No. 13	5 ft.-0 in.
Perforated metal	Under 4 in.	½ in.	No. 20	6 ft.-0 in.
	4 in. to 15 in.	2 in.	No. 14	5 ft.-0 in.
Sheet metal	Under 4 in.	—	No. 22	6 ft.-0 in.
	4 in. to 15 in.	—	No. 22	5 ft.-0 in.
Wood or metal strip not crossed	Under 4 in.	½ in.	Wood ¾ in. Metal No. 16	6 ft.-0 in.
	4 in. to 15 in.		Wood ¾ in. Metal No. 16	5 ft.-0 in.
Wood or metal strip	Under 4 in.	½ in. width	Wood ¾ in. Metal No. 16	6 ft.-0 in.
	4 in. to 15 in.	1 in. width	Wood ¾ in. Metal No. 16	5 ft.-0 in.

APPENDIX G

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